THE MANNER OF COPULATION IN A TURBELLARIAN WORM, *PLANARIA MACULATA*.[1]

ROBERT A. BUDINGTON.

During the summer of 1920, while observing rather large numbers of flatworms, *Planaria maculata*, the writer chanced upon a quite ideal opportunity for watching copulation habits in that species. The worms were in a watch-glass which was easily transferred to the stage of a binocular dissecting microscope, and the attitude and relation of the mating worms thus became readily noted. Later they were killed, while still copulating, with a hot corrosive-acetic mixture; and although the worms separated during this treatment, the fixation was rapid enough so that the penes of the killed worms were preserved in very protruded condition.

Referring to the incident in conversation with several zoölogists, it seemed that they had never observed turbellarian copulation, nor did they remember having seen it described. On looking for data regarding it, it has not been possible to find any account of it either in the larger treatises or in more extended special papers on flatworm anatomy and behavior. Curtis, '02, who worked upon the "Life History, Normal Fission, and Reproductive Organs" of this same species for three years, informs me that he did not observe copulation. His studies were so extended, both in numbers used and in period of time, that one is inclined to conclude that either the procedure is not very frequent or that it is of short duration in any given instance.

Since there seems this gap in the recorded descriptions of this worm's total behavior, the following paragraphs are offered as supplementing our knowledge of it, as well as indicating what may be the impregnation process in turbellarians in general; for if, indeed, the process has not been much or at all studied, there may exist even so elementary a question as to whether or not the short copulatory organ is protruded through the atrial pore at all;

[1] From the Department of Zoölogy, Oberlin College, and the Marine Biological Laboratory, Woods Hole.

or whether the spermatozoa may not be deposited in the atrial cavity of each worm and an exchange of them be effected by simple apposition of the pores, as is essentially the case in Annelida, also hermaphrodite.

Contrary to the behavior of oligochæte annelids which adhere in pairs, with anterior ends pointing in opposite directions, two *Planaria maculata* mate with heads in the same direction (Fig. 1).

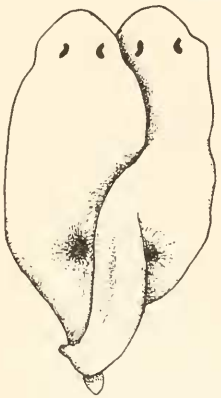

FIG. 1. Attitude assumed by two *Planaria maculata* during copulation.

The anterior ends are maintained side-by-side and flattened on the supporting substance (bottom of watch-glass in this case), oriented alike. About one third of their length posteriorly there begins a rather slight spiral twisting of the flat, oral surfaces of the worms against one another, so that the left ventral side of the right worm of a pair becomes lifted up against the right ventral side of the left worm. This twisting is carried further, posteriorly, so that the tail ends of the worms may even cross one another. At a point on the dorsal surface of each, opposite the external opening (genital pore) of the atrium, there was a marked depression caused by the extension of the penis directly underneath. This indicates that the penis of each worm is drawn into the atrial cavity of the copulating mate by a definite muscular grasp on the part of the walls of the enveloping atrium. This is also suggested by the narrowing of the proximal end of the extended penis; this is evident in Fig. 2. The relation of the two copulants is thus presumably as in Fig. 2; this is purely a diagram, however, and one may not infer that the penes necessarily lie laterally to

one another always, for there may be no constancy in this detail of relations; the laterally side-by-side position, however, would seem better to permit approximation of each copulatory organ to the intra-atrial opening of the uterine duct of its mate.

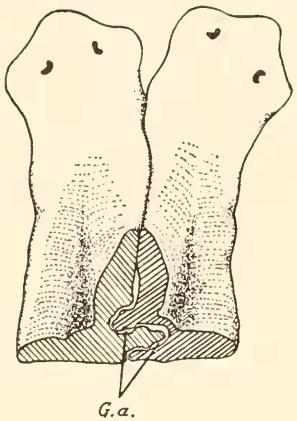

FIG. 2. Diagram of two mating worms cut transversely at level of the genital atria. *G.a.*, Genital atria.

Impregnation in this species is thus mutual and simultaneous between the members of a pair. The period of time over which

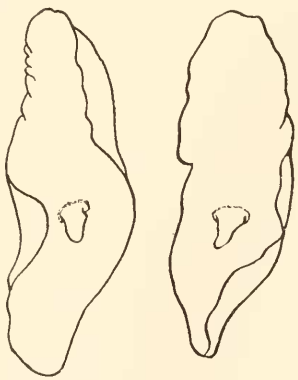

FIG. 3. Outline drawings of two ex-copulant flatworms after fixation. The penes still protrude.

they maintain this relation was not secured as it seemed desirable to fix the worms while copulation was in progress. Fig. 3 shows careful outlines of the two excopulants after fixation, showing relative size of body to copulatory organ, etc.

To determine certain points relating to internal organs, serial sections were made of one of the pair; fixation proved to be satisfactory. As to the normal anatomy of the reproductive organs, the description and figures given by Curtis[1] are wholly adequate and correct. Naturally in the process of copulation the terminal portions of the vasa deferentia become adjusted to the protruded penis; and for the sake of easy comparison, Curtis's

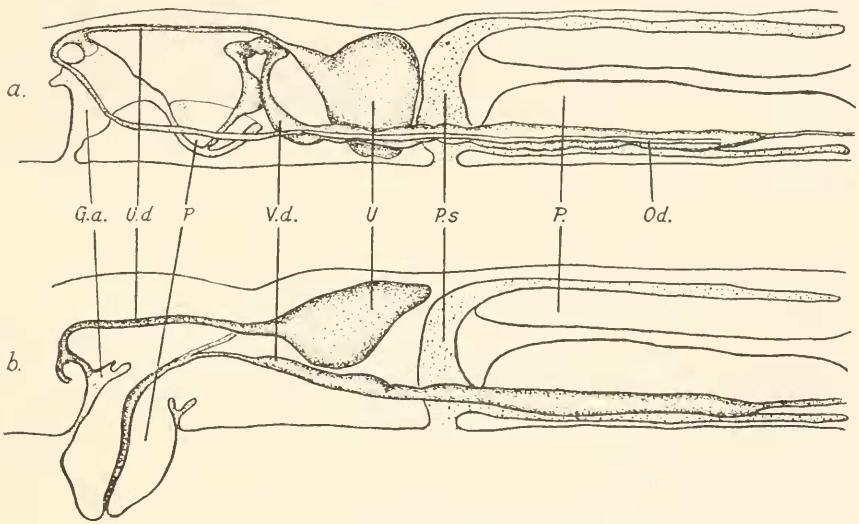

FIG. 4. (*a*) Normal resting position of the reproductive organs of *Planaria maculata*, from lateral aspect. (After Curtis.) *G.a.*, Genital atrium; *Od.*, Oviduct; *Ph.*, Pharynx; *P*, Penis; *U.*, Uterus; *U.d.*, Uterine duct; *V.d.*, Vas deferens. (*b*) Same as (*a*), with organs in position during copulation.

figure of the retracted arrangement of these organs is reproduced beside one drawn from the same aspect with the penis in copulating position. No comment seems necessary by way of interpreting these figures; in mating, the penis is turned posteriorly, extended through the atriopore, and considerably enlarged. This change in position tugs on the vasa deferentia (seminal vesicles) and straightens out the loops which occur in them when at rest.

Concerning the place of deposition and storage of the transferred sperm, a further word may be added. The cavity of the

[1] Curtis, W. C., *Proceedings of the Boston Soc. of Nat. Hist.*, Vol. 30, No. 7, 1902.

atrium is considerably obliterated by the position of the penes; but the remaining space is more or less filled with spermatozoa, as is also the neck of the uterus, although this latter is very narrow and in the sectioned material it shows but a thin trail of sperm. As its wall is heavy with circular muscle, it is probable that it forced its contents along into the uterus while the fixation was still superficial. It also seems likely that few, if any, sperm are retained in the atrium after copulation is over; any such would be expelled through the external pore. The result of copulation will therefore be the reception of spermatozoa into the uterus of each copulant. This sperm mass in the uterus is (at least during copulation as here studied) in the form of a coiled cord or skein-like mass surrounded by mucus.

Gamble states in the section on Turbellaria in the Cambridge Nat. Hist., Vol. II., p. 38, that the copulatory organ when extended is long and narrow enough to reach up into the neck of the uterus; and that the eggs and sperm meet in that cavity. The present observations do not permit a denial of that statement; but the size of the organ as against that of the uterus duct as seen in Fig. 5 seems to make such an insertion, in *Planaria* at least, very improbable.

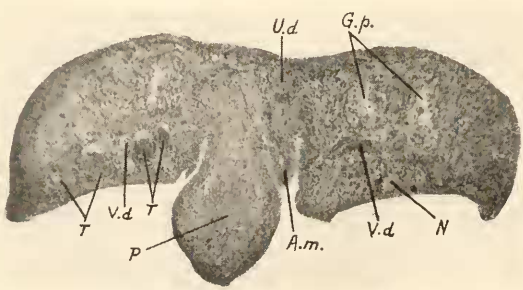

FIG. 5. Transverse section of *Planaria* at level of atrium, during copulation. *A.m.*, Atrial margin; *G.p.*, Gut pouches; *N.*, Nerve; *P.*, Penis; *T.*, Testes; *Ud.*, Uterine duct; *V.d.*, Vas deferens.

Again, although it is well known that in many forms the eggs are passed up into the uterus and meet the sperm there, in the present instance the uterus, as shown in sections, contains only sperm embedded in a mucus mass. The statement is often made that the sperm cells are aggregated into spermatophores; in a

study of a single section this does seem to be the case, but further examination shows the spermatozoa to be in a long skein, much coiled, and surrounded by mucus. For a time at least the uterus may function merely as a sperm receptacle.

Summary.

1. *Planaria maculata*, and probably many other triclad Turbellaria, mate with both copulants oriented in the same manner.

2. Impregnation is mutual, and simultaneous.

3. During copulation the vasa deferentia are much distended by their sperm contents, while the uterus may act temporarily as a sperm receptacle only.